Journal of STI Policy and Management

Publication details, including instructions for authors and subscription information: http://www.stipmjournal.org/

Development Strategy of National Microsatellite Industry: Case Study of Indonesia

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Version of record first published: 15 December 2018

To cite this article: Judianto, C.T., Harianto, and Maulana, A. (2018). Development Strategy of National Microsatellite Industry: Case Study of Indonesia. *Journal of STI Policy and Management,* 3(2), 145–159

To link to this article: http://dx.doi.org/10.14203/STIPM.2017.140

ISSN 2540-9786 (Print); ISSN 2502-5996 (online)

Accreditation Number: 21/E/KPT/2018

JOURNAL OF SCIENCE, TECHNOLOGY, AND INNOVATION POLICY AND MANAGEMENT (STIPM JOURNAL), Volume 03, Number 02, December 2018

FOREWORD by EDITOR-in-CHIEF

We are very pleased to inform the readers that Journal of *Science, Technology, & Innovation Policy and Management* (STIPM Journal) Vol. 3, No. 2, December 2018 is now ready for public reading and views. STIPM Journal is an online research journal, managed by the Center for Science and Technology Development Studies, Indonesian Institute of Sciences (PAPPIPTEK-LIPI).

This journal in fact provides scientific information needed mostly by research scholars. As a peer reviewed journal, STIPM provides free public access to all articles. Two issues, namely scientific review on variables and dimensions of national innovation capability, as well as research findings on development and adoption of science, technology, and innovation policy and management from Japan and Indonesia, are presented.

The first article "Internal Innovation Capacity and External Lingkages in Firms of ASEAN Economies Focusing on Endogeneity" is composed by **Masaru OGAWA et al.** This research article examines the role of internal innovation capacity, which includes technological level, organizational learning, and human resources on innovation. The second research article entitled "Drivers of Innovation without Formal R&D: Selected Cases of Indonesian Firms". This article is presented by **Erman AMINULLAH et al.** The objective of this research study is to obtain a deep understanding about "why and how" firms engaging in innovation without formal R&D, through deep analysis of three cases of firms in machinery and food processing sectors.

Uruqul Nadhif DZAKIY presents an article entitled "Technology-based Start-up: A Formula to become Sustainable Company in Indonesia, Lessons-learned from UAVINDO Nusantara". UAVINDO is a sample of technology-based company in Indonesia which has the characteristics of sustainable company. The fourth article entitled "Development Strategy of National Microsatellite Industry: Case Study of Indonesia", is presented by **Chusnul Tri JUDIANTO et al.** By applying SWOT and Quantitative Strategic Planning Matrix (QSPM) methods, this research identifies and analyzes the alternative strategy from external and internal factors and selects the appropriate and precise strategy for developing the microsatellite industry.

Hadi KARDOYO et al. present an article entitled "Knowledge Accumulation-based Entrepreneurship in the Creative Industry: A Case Study of Woodwork Firms in Indonesia." This article describes the activities of knowledge-entrepreneurship in four wood craft firms, namely Radio Magno, Stranough Guitar Technologi, Secco Guitar, and Matoa Watch, and also shows some lessons from Knowledge Intensive Entrepreneur (KIE). The last article composed by **Ahmad Dading GUNADI et al.** presents a "Scientifc Review on National Capability Variables and Dimensions." This paper analyses the dimensions and variables of National Innovation Capability through a system approach that includes three sub-systems, namely Input, Process, and Output.

After indexing by Google Scholar, ISJD and IPI, STIPM Journal is now indexed with DOAJ, BASE, and OCLC World Cat. This has made the journal's dissemination broader. We would like to express our immense gratitude to our international editorial board members, reviewers and authors for their contribution to this issue. We hope this publication will prove useful for readers and could contribute to the enhancement of science, technology and innovation innitiatives. We expect that STIPM will always provide a higher scientific platform for authors and readers, with a comprehensive overview of the most recent STI Policy and Management research and development at the national, regional dan international levels. Finally, wishing you a *HAPPY NEW YEAR 2019. May your New Year be filled with great achievements, good health, peace, happines, and joy*.

Jakarta, December 2018

Editor-In-Chief

JOURNAL OF STI POLICY AND MANAGEMENT

Volume 3, Number 2, December 2018

LIST OF CONTENTS

Journal of STI Policy and Management, 3(2) 2018, 145–159

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STI POLICY AND MANAGEMENT

Journal homepage: http://www.stipmjournal.org

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Development Strategy of National Microsatellite Industry: Case Study of Indonesia

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ARTICLE INFO

Article History:
Received : 09 July 2018
Revised : 05 December 2018
Accepted : 09 December 2018
Available online : 15 December 2018

Keywords:
COTS
Microsatellite
MEMS
QSPM

ABSTRACT

Indonesia is the largest archipelagic country in the world; 13,466 islands with total land area of 1,922,570 km^2 and sea area of 3,257,483 km^2. Controlling and monitoring this huge area using satellite technology is possible, and the self reliance of space technology is a way to maintain satellite data security. Remote sensing data, telematics and communication are needed for many applications for people and industry. Development of satellite technology for developing country can be achieved since the utility of the Micro-Electrical-Mechanical Systems (MEMS) and Commercial off The Shelf (COTS) components meet the microsatellite basic technology requirement. Indonesia has some experience of microsatellite research for surveillance, remote sensing, ship monitoring and science through National Institute of Aeronautics and Space (LAPAN). Sustainability of the microsatellite technology mastery needs support from government regulation, commercial cooperation with private company and collaboration research with university for space technology innovation. By using the SWOT and Quantitative Strategic Planning Matrix (QSPM) methods, this research identifies and analyzes the alternative strategy from external and internal factors and selects the appropriate and precise strategy for developing the microsatellite industry. The research shows that standardization of a satellite system, product, method, human resources and financial support with new investor using Public Private Partnership (PPP) schemes, as well as utilization of international cooperation with other countries, are the entrance for space industry.

I. INTRODUCTION

The specificity condition of the territory of Indonesia that has total land area of 1,922,570 km^2 and sea area of 3,257,483 km^2 with 13,466 islands makes the level of demand for satellite technology very high, compared to other countries. With the development of the digital era, the need for satellite technology is for not only for communication, but also various applications such as remote sensing for earth observation of agricultural, plantation, urban, forest, coastal

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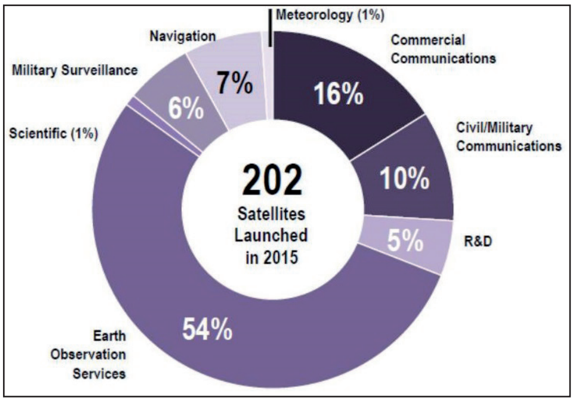
http://dx.doi.org/10.14203/STIPM.2017.140

and sea areas for various needs. In addition, satellite technology applications are developed for disaster mitigation as well as for atmospheric observations, weather and climate predictions (weather satellites), navigation satellites, scientific satellites and communications satellites. The development of global satellite industry, which continues to grow annually with 3% growth and revenue of $208.3 billion (SIA, 2016), shows the growing trend of demand for this technology by developing countries. As satellite technology evolves, the trend in the last ten years has shown that satellite production is directed at satellites under 500 kg of weight (small satellite). From 202 satellites launched in 2015, 49% are small satellites used for earth observation, R&D, military, scientific and meteorological missions (SIA, 2016). This growth in the use of small satellites has been primarily driven by the miniaturization of electronics and sensors and the availability of commercial off the shelf (COTS) components with increasing capability, significantly reducing the cost of hardware development (Crisp, Smith & Hollingsworth, 2015). It is possible to develop a microsatellite independently even with a small of budget, lack of human resources and facilities. The independence of satellite technology will need to meet data security standards and its applications tailored to the national needs and abilities. Small and cost-effective missions are powerful tools to flexibly react to information requirements with space-borne solutions. Small satellite missions can be conducted relatively quickly and inexpensively by using commercial off the shelf technologies, or they can be enhanced by using advanced technologies (Sandau, Klaus & Marco, 2010).

Meanwhile, the opportunity for microsatellite launch is increasing significantly by piggy-back mode. The projected number of nano/microsatellite launched in 2017 has an increase by 80% compared to 2016 with 128 launches of commercial earth observation satellite and remote sensing satellite constellation (SEI, 2017). The commercial satellite launcher such as Atlas (US), PSLV (India) and H2D (Japan) are very effective in bringing nano/microsatellite type to orbit. This is the opportunity for countries to launch their



Source: SIA (2016)

Figure 1. Number of Spacecraft Launched by Mission Type in 2015

satellites, especially for developing countries which are starting to develop their space program.

Indonesia has developed microsatellites for various missions. One of them is LAPAN-A3/IPB. That collaboration between National Institute of Aeronautics and Space (LAPAN) and Bogor Agricultural Institute (IPB) has produced image data of Indonesian territory taken from 505 km height. The LAPAN-A3/IPB satellite became the first remote sensing experimental satellite developed by Indonesia with a downstream speed of 105 Mbps data in CCSDS standard format (Judianto & Nasser, 2015). The ability of this satellite is to observe agricultural land with a resolution of 16 m and 100 km swath and shipping traffic monitoring of global water territory. Future satellite technology development trends are the development of satellites that apply miniaturization technology and micro-electrical-mechanical systems (MEMS) technology that enables enhanced capability and the ability of satellites. Indonesia has implemented this technology for its satellite technology independence.

In space industry perspectives, the space industry ecosystem requires two main sectors, first focus on upstream segments for design, manufacturing, assembly and launch of satellites to orbit; and second is to focus on downstream segment such as satellite utilization for telecommunication, navigatioan and earth observation for weather prediction, crop analysis, disaster management and mitigation. Meanwhile, space activities support also plays an important role such as development factor consisting of research centre, government, infrastructure, associations and internal organization. On the other hand, space services factors are also important to conduct legal services, financial services, insurance, consultancy, advocacy, defence, project management and space education and training (Lania, 2016).

II. ANALYTICAL FRAMEWORK

Satellite development in Indonesia first started in 1976, when the first telecommunication satellite of Indonesia named Palapa-A was made and launched by Huges USA. Communication satellite business in Indonesia has developed since, supplying many satellite services especially for fixed and mobile communication, internet and banking. For more than one decade, LAPAN has seriously tried to develop Indonesian satellites for surveillance and earth observation missions. It started from experimental microsatellites using international cooperation scheme.

Some reasons to build space technology in developing countries are the government's and people's need: a national prestige and pride, a policy of self-reliance, and for strategic considerations. Sustainability in a space program also needs strong scientific leadership, particularly from the central role played by a national space agency, foreign technological inputs, strong local effort, linkages between various institutions and maybe because of pressure from export control regimes (Baskaran, 2005).

A. Microsatellite Program in Indonesia

In 2003, Indonesia started its satellite program led by LAPAN. Most space researches have been done to support the satellite program using cooperation with other institution from foreign countries. The first Indonesian microsatellite named LAPAN-TUBSAT or LAPAN-A1, was launched from India using PSLV-C7 on February 2007, as a result of the technical cooperation with TU-Berlin Germany. Some engineers also involved in design and built the satellite using TU-Berlin facilities. The satellite brought the mission for attitude control system (ACS) technology demonstration and earth surveillance. Numbers of object on earth were captured, target positions were analyzed and standard operation procedure for satellite operation was developed. The satellite was operated in polar orbit at 630 km height (Judianto, 2013).

The second satellite named LAPAN-A2 was launched on September 2016. It has a special payload for technology enhancement of surveillance mission and automatic identification system (AIS) payload for monitoring the shipping traffic on sea surface entire equator at 8 degree north and south. Due to Indonesian islands spread out from 95 degree east to 140 degree east, this type of orbit is very important and more beneficial for Indonesia and many countries in equatorial region. At that time, new technology was applied to control the movement of the satellite for automatic focus (automatic target pointing). Achievements from this satellite mission are very strategic because the data are utilized by government, private company and university.

LAPAN has been continuing to develop the microsatellite series for many purposes, such as remote sensing, scientific research and communication. LAPAN-A3/IPB is the first microsatellite dedicated for remote sensing mission collaboration with Bogor Agriculture University (IPB), and it has been operating since 2016.

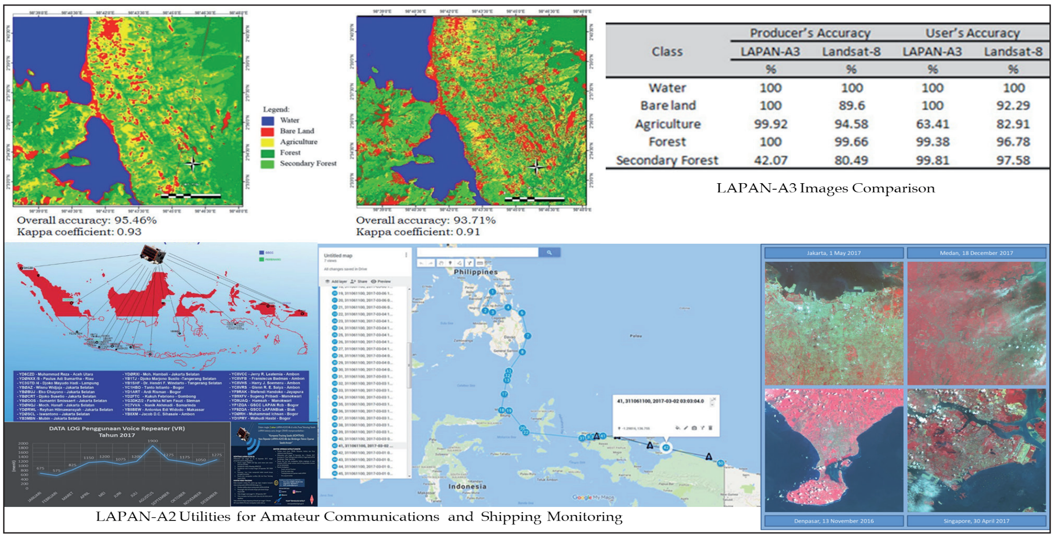
Fast growing microsatellite technology for human needs is an opportunity to build the national satellite industry, supported by local companies for specific products and services. LAPAN has done some satellite projects and will continue the satellite experiment and operational satellite program to meet the need of community for data and information. Enhancement of the competence of human resource in space technology and build the cooperation technology with numbers of space agencies, national private companies and universities are the primary program in-line with the satellite development program.

Collaboration in development of microsatellite for specific purposes is also one of the transfers of knowledge scheme. For this type of collaboration, each institution has to build their facilities and shared them with others. Some satellite facilities have been built by LAPAN and can be shared for national satellite project activities such as the following.

Parameter / Mission	LAPAN-TUBSAT	LAPAN-A2/ORARI	LAPAN-A3/IPB
	Video surveillance	Earth Surveillance, Maritime Monitoring, Amateur Communications	Imager Remote Sensing Experiment, Global Maritime Monitoring, Science Experiment
Payload	Sony Color Video Camera Kappa Color Video Camera	4M Pixel Digital Camera AIS, Analog Camera, APRS	4 Band Push broom Imager, 4M Pixel Digital Camera
Spectral Resolution	RGB Kappa PAL, Color Camera (CCD 700X700 pixel)	RGB Digital Visible Camera (CCD 2048 x 2048 Pixel)	Band 1: 450 – 520 nm Band 2: 520 – 600 nm Band 3: 630 – 690 nm Band 4: 760 – 900 nm
Spatial Resolution	5 m (3.5 km x3.5 km) 200 m (80 km x 80 km)	5 m (12 km x 12 km) 5 m (3.5 km x 3.5 km)	8 m (100 km Swath Width) 6 m (12 km x 12 km)
Orbit/Inclination	635 km/97.6 °(deg)	650 km / 8 °(deg)	650 km/97.6 °(deg)
Communication TX Payload TTC	 S Band UHF	 S Band UHF	 X Band UHF
Down Link Rate	5 Mbps	5 Mbps	105 Mbps
Total Weight	55 kg	78 kg	115 kg
Dimension	45 x 45 x 27 cm²	50 x 47 x 38 cm²	55 x 50 x 70 cm²
Launch	January 10, 2007	September 27, 2015	June 22, 2016

Source: Judianto (2013)

Figure 2. Indonesia Microsatellites in Orbit



Source: LAPAN (2017)

Figure 3. LAPAN Microsatellite Utilitites

Source: LAPAN (2017)

Figure 4. Satellite Test and Ground Control Facilities of LAPAN

B. Satellite Test and Laboratory Facility

1) Laboratory

   Assembly integration and test laboratory for satelit micro (< 300 kgs, clean room class 100.000), optical laboratory (clean room class 10.000), elecronics and communication laboratory, mechanical workshop.

2) Satellite Test Facilities

   Thermal vacum chamber, vacum chamber, spectrum analyzer, air bearing system, digital oscilloscope, dc loader, logic analyzer, signal generator, frequency counter, soldering qualification check, wiring qualification test and software such as satellite toolkit (stk), cam nx 6 solidedge, s/w oslo (design optic), codevisionavr advance version.

C. Ground Contol

1) 11.3 meter dish with elevation over azimuth and train positioner (3-Axis)
2) X-Band receiver high performance with AUTO-Track Program, 8GHz – 8.5GHz
3) S-Band receiver & transmiter with AUTO-Track Program, Rx (2.2GHz – 2.3GHz) and Tx (2.025 GHz – 2.120 GHz)
4) S-Band TT&C system with 100W SSPA
5) High data rate receiver demodulator
6) CCSDS data format support
7) Satellite support from LEO (>250 Km) Up to GEO orbit

Referring to the result study from SpaceWorks Enterprise Inc. (SEI, 2017), 2,400 microsatellites will be developed by 2023 for various missions such as remote sensing, telecommunication, research and military. The trend of microsatellite technology grows exponentially every year because of low cost technology available and open to any country and company. Opportunities for satellites and launching providers such as India, China, Russian and European Space Agency (ESA) are gradually increasing.

This growth in the use of small satellites has been primarily driven by the miniaturization of electronics and sensors and the availability of commercial off the shelf components with increasing capability, significantly reducing the cost of hardware development. The access to orbit and the economics of these spacecraft is also improved through availability of secondary payload launch opportunities (Crisp et al., 2015). Satellite technology and launch opportunity are open for any country to start their space program. Microsatellite programs are unique and interesting to be developed because of their cost and technology availability. Therefore, in 2015 from 202 satellites which were launched, 108 or 49% of them are small satellite for earth observation, R&D, military, scientific and meteorology (SIA, 2016). Microsatellite is part of the small satellite class between 0 to less than 1,000 kg as mentioned in Table 1. Microsatellite has weight between 10–100 kg and Indonesia has made some microsatellites in that range of weight, and plans to make larger ones.

Establishment of space industry needs government penetration for regulations and also initial financial support. Meanwhile, the government also has to consider the economic and political condition because the macroeconomic environment and stability plays an important role at national level and it is related to the international competitiveness of a country (Herciu, 2013). Some space industry business models, followed by global space industry, can be studied and adopted for the Indonesian circumstance shown in Table 2. By using public private partnership (PPP) financial scheme, the commertialization of microsatellite can be defined and bring benefits for the government and private companies.

The feasibility of space technology in a developing country depends on many factors related to the country itself, such as human capital, maturation level of related high-technology capabilities, regional and international relations, economic, geographic and demographic scale of the country and even its geographic location

Table 1.
Satellite Type and Weight Standardization

No	Satellite Type	Weight	
1	Large Satellite	> 1,000 kg	
2	Medium Sized Satellite	500–1,000 kg	
3	Mini Satellite	100–500 kg	Small Satellites
4	MicroSatellite	10–100 kg	
5	Nano Satellite	1–10 kg	
6	Pico Satellite	0.1–1 kg	
7	Femto Satellite	< 0.1 kg	

Source: Sandau (2016)

Table 2.
Space Industry Business Models

No	Schemes	Space Industry Examples
1	Services contracts operation and management contract	▪ Contract between CNES and private sector to create Arianspace. ▪ Man power contract at NASA and ESA for operational work at spaceport and ground station.
2	Leasing type contract ▪ Build-buy-operate ▪ Lease-develop-operate ▪ Wrap around addition	Boeing Space System and Locked Martin using this type of contract for Launcher Operation (Delta IV and Atlas V).
3	Build operate transfer ▪ Build-own-operate-transfer ▪ Build-rent-own-transfer ▪ Build-lease-operate-transfer ▪ Build-transfer-operate	Wideband Global System (WGS) created by US Dept. of Defence to operate its eight constelation satellites.
4	Design-build-finance-operate ▪ Build-own-operate ▪ Build-rent-own-transfer ▪ Build-design-operate ▪ Design-construct-manage-finance	Satellite fleet operators (Intelsat).

Source: Nagendra and Basu (2016)

(Leloglu & Kocaoglan, 2008). Indonesia needs such technology to establish the international relationship and expand the national economy from the opened-up opportunity of a growing local and regional market in south Asia and the Pacific.

D. Satellite Business in Indonesia

The satellite programs are run following the tight schedule because building the satellite needs both administration and technical expertise. There are some events which have to be considered, done appropriately and run sequentially.

Source: ASSI (2016)

Figure 6. Satellite Business Chain

Before starting to build a satellite, the company provider has to ensure the filling of the satellite. This filling includes notification administration of user (government), name of the satellite network, orbit type, orbit slot and technical parameter such as frequency use, frequency band width, coverage, emission power and antenna type on the ground and the need of frequency coordination with other users from other countries (ASSI, 2016). Those parameters are firstly registered to the International Telecommunication Union (ITU) through the local government administration to obtain the right for using the specific frequency, orbit, and so on.

Referring to the Indonesian Space law No. 21/2013, it is mentioned that the government institution have to provide the national satellite program, satellite manufacture and facilities development, satellite system test, satellite operation and satellite launching. National regulation for satellite development is also mentioned in the President Decree No. 45/2017, with emphasis on national satellite road map from 2016–2040. The establishment of a value chain in the space sector involves development of technological, regulatory, and policy infrastructure, which performs with synergy and delivers with high reliabilities (Nagendra & Basu, 2016).

The microsatellite project is a part of the national satellite program that initially starts from using microsatellites, until large satellites are used for communication and earth observation. It means that the opportunity to develop national satellite industry is obviously opened. Because of the availability of satellite technology, some collaboration projects on microsatellite technology had been conducted by LAPAN. In this condition, LAPAN is able to push the microsatellite research to commercialization by collaborating with national private companies and try to speed up the start-up company in satellite business. This research will focus on the possibility of microsatellite business development in Indonesia.

E. National Microsatellite Industry Current Position

Space commercialization in Asia Pacific have grown faster to fulfill the need of people to get specific, accurate and real time information of their environments. China, India and Japan are the leaders in space industry in this region. Nowadays, the development of satellite technology has opened up in some developing countries. Therefore, some have started their space programme to provide their own space technology and build local space industry, such as Indonesia, Vietnam, Thailand, the Philippines, Malaysia and Singapore. Even though they have a growing satellite program for communication and operational remote sensing satellite as a result from collaboration with international satellite providers, they have created their own satellite technologies through microsatellite program. According to the Porter's diamond, that fact is also known as the theory of national competitive advantage of industries, mentioning that the determinants of competitive advantage depend on four conditions. Those conditions are factor conditions, demand conditions, the related and supporting industries and the firm strategy, structure and rivalry (Porter, 1990).

1) Factor condition; the advantage factors found within a country that build competitive advantages such as human resources, capital resources and infrastructure.

2) Demand condition; shows how favorable industries are able to run their businesses properly because of high demand for certain products.
3) Related and supporting industries; local company which is supporting the national industry to create additional value for the customers and enhancing innovation and finally make the national industry more competitive.
4) Firm strategy, structure and rivalry; how the company management has the potensial of affecting competitiveness.

If these conditions are favorable, then it will force the domestic company to compete in the international industry. For national microsatellite product, competitiveness can be described using Porter's diamond in Table 3. Some competitiveness factors show that for factor of condition, Indonesia still has great advantages although enhancement, especially in financial support, is much needed. Meanwhile, there is demand in regional market where every country is starting their national space program instead of buying the technology from developed countries such as the US, Europe Space Agency (ESA), Russia, China, Japan and India. Utilization of satellite technology in Indonesia is growing. This progress on microsatellite development and ground satellite services means that it is essential to create new small and medium enterprises (SMEs) to support national space industry. Based on these competitive advantages, the new emerging SMEs can be supported by government regulation and international collaboration and cooperation.

III. METHODOLOGY

This study used a SWOT analysis, looking at the strength, weakness, opportunity and threat to identify internal and external factors affecting Indonesia to build the microsatellite industry. The strength and weakness were derived from the internal environment condition including the existing research and development resources (software and hardware infrastructure, patent, innovation and human resources). The external environment condition drives the opportunity and threat including markets, political condition, regulation and business competition that should be faced to plan the microsatellite industry.

Resource data used in this research came from intensive discussions, in-depth interviews, field observation and questionnaires (primary data) from satellite researcher, satellite com-

Table 3.
Porter's Diamond for Indonesia's Microsatellite Industry

Diamond Determinant	Competitive Advantages	Competitive Disadvantages
Factor condition	▪ Availability of microsatellite Assembly Integration and Test facility, ground station control ▪ Skill full human resources in technology and satellite applications ▪ experiences on building and launch the microsatellite	▪ Availability of financial support ▪ Quality of some supporting infrastructure ▪ Numbers of competence human resources
Demand condition	▪ Market size in utilization of microsatellite for earth observation, shipping monitoring, communication and surveillance ▪ Satellite data application, web base and android base	▪ Poor investment in microsatellite R&D
Related and supporting industry	▪ Internet/VPN service and networking supporting equipment ▪ Data processing services ▪ Microsatellite component ▪ Ground satellite services	▪ Local component supplier quality and quantity ▪ Local scientist quantity ▪ Space research from university
Firm strategy, structure and rivalry	▪ Technology collaboration and project cooperation ▪ Government regulation support	▪ specific study of space technology and application in local university ▪ Technology Readiness Level (TRL) of Space Technology

munity and goverment. The secondary data were obtained from satellite document, satellite strategic plan of LAPAN, government regulation, satellite technical document and business prespective from satellite association.

The appropriate strategic plan was identified and analyzed using quantitative strategic planning matrix (QSPM) method. This method found the attractiveness of alternative strategic options to build a strategic plan to be implemented in Indonesia.

Conceptually, the QSPM determined the relative attractiveness of various strategies based on the extent to which key external and internal critical success factors are capitalized upon or improved (David, 2011). This research showed the attractiveness of some development of micro satellite strategy in Indonesia based on people's needs (data and technology), Internet of Thing (IoT) technology trend, satellite technology development in Indonesia and political environment.

V. RESULTS AND DISCUSSION

Indonesia has the experience in building the microsatellite system, dealing with Ministry of Communication and Informatics (Kemenkominfo) and International Telecommunication Union (ITU) for filling the satellite, launch campaign, maintain the satellite in orbit, preparing the ground station, acquisition and dissemination of the data and information to users. This experience is a sound basis for microsatellite technology development to support the need of many users in Indonesia. Indonesia has microsatellite development facilities, skilled human resources, sound methodology in space research and a captive market for satellite uasage, data and information. However, the support for space SMEs grows very slow because of an unsupported local space industry. The space research is carried out only by government institution (LAPAN). Every subsystem of microsatellite technology development has been created from scratch. LAPAN has driven microsatellite technology since 2003, forming the basis to build the national sovereignty in microsatellite development. LAPAN has experience in satellite engineering, international cooperation on satellite technology collaboration, satellite operation and data utilization. Since they launched the first microsatellite, they started to learn how to handle import and export of specific space material from other countries and manage documents for launch campaign, negotiation for using specific frequency with local institution (Kemenkominfo) and international institution (ITU). Finally, they had confidence to launch the second and third microsatellite. Those are the experiences that can become their strengths to initiate a new industry in Indonesia. The government also has strong vision to become the centre of excellence in satellite technology and applications. It means that LAPAN, as a government institution, which conducts the national space technology and application, has a strong commitment to carry out specific missions to develop and enhance satellite technology and application, for human needs and open new markets.

Those are some strength factors required in planning the microsatellite development in Indonesia (Table 4). Those factors are able to drive the government of Indonesia to be more confident to realize the national satellite program, as mentioned in Indonesia's Space Law No. 21/2013, and supported by Presidental Decree No. 45/2017 on National Space Master Plan 2016–2040 that elaborates the stage of achievement for every 5 years. This is a great motivation for any institution to support space industry starting from satellite technology development for national sovereignty and national pride.

The key success factors for building the industrial capacity in an emerging space country are international cooperation, partnerships, supportive regulatory environment and innovation and technology transfer (Esterhazy, 2009). Currrently, Indonesia has an international cooperation in satellite technology and ground services with TU Berlin Germany, Indian Space Research Organization (ISRO), Tohoku University Japan and local university (Telkom University, Hasanuddin University, Bogor Agriculture University, University of Indonesia, etc) and private company (PT Telekomunikasi Indonesia) to conduct microsatellite development and utilization of its data and information. Technology transfer of microsatellite technology has been done with TU Berlin Germany since 2005, which resulted in three microsatellites operating in low earth orbit (LEO) around 500–1,000 km from the earth surface. Compared with the space program of several countries at regional South East Asia, Thailand started their space program by building TM-Sat in 1998 with the assistance of University of Surrey, UK. Malaysia developed and launched their first microsatellite Tiuangsat-1 on 2000 with assistance of University of Surrey and then another satellite named Razaksat-1 cooperating with Korean company Satrec Initiative Co. Ltd. (Kim et al., 2003), Razaksat-2 is planned to be launched in 2019. Meanwhile, Singapore started their space program by building microsatellite Uosat-12 from University of Surrey. Then they developed their second satellite X-Sat in collaboration with Satrec Initiative Co. Ltd. Korea, ISRO India and DLR Germany and launched on 2011 (NTU, 2016). The owner of these microsatellites is Nanyang Technology University. Now, Singapore has a commercial satellite project conducted by private company, Singapore Technology Engineering (STE) with their satellite Teleos-1 (400 kg) launched on 2016 and prepared to launch their second satellite, Teleos-2. These are examples of opportunities for Indonesia to strengthen national space technology which is supported by government, university and local private company. The government has to support the development of SME through a condusive space industrial ecosystem in Indonesia. New investment scheme, such as PPP, can be created by government as part of government-to-business (G2B) cooperation. Satellite telecommunication business experienced in Europe shows that the PPP investment model is an efficient method for commercial and institutional customers (Franzolin, 2009).

There are some of strategic alternatives carried out as part of SWOT identification of internal and external factors explained in tables 4, 5, 6 and 7. These strategic alternatives come from deep interview and focus group discussion with expert and decision maker on satellite business by looking at the impact of internal and external factors. These strategic alternatives are summarized as follows.

Strength/opportunity strategy:

1) Build the center of excellence for satellite technology
2) Synergy of government, university and private company to create the start up space industry.
3) Microsatellite constellation project for support some missions
4) People space awareness

Tabel 4.
Strengths

No.	Internal Factors	Weight	Rating	Weighted Score
	Strengths			
1	Vision of LAPAN: to be the national satellite excellence centre	0.06	4.00	0.24
2	Ground station control and satellite data network worldwide	0.04	3.00	0.12
3	Experience on operation and maintenance of microsatellite in LEO orbit	0.05	3.00	0.15
4	Experience on technology collaboration on satellite technology and application development with other space agency and international university	0.05	4.00	0.20
5	Competency and experience of engineers on microsatellite development and control.	0.06	4.00	0.24
6	National pride on space technology	0.06	4.00	0.24
7	Infrastructure of imagery laboratory; optic laboratory class 10,000; assembly integration and test laboratory class 100,000 for satellite	0.05	4.00	0.20
8	ICT infrastructure availability	0.06	4.00	0.24
9	Experience on data utilization of communication and remote sensing technology as well	0.04	4.00	0.16
10	Ability for managing the micro satellite orbital filling (LAPAN-TUBSAT, LAPAN-A2 and LAPAN-A3) at International Telecommunication Union (ITU) and International Amateur Radio Union (IARU)	0.05	3.00	0.15
	Total (A)	0.5		1.88

Tabel 5.
Weakness

No.	Internal Factor	Weight	Rating	Weighted Score
	Weakness			
1	Lack of budget for satellite research and development	0.05	2.00	0.10
2	Indonesia still in the position as data user only (receive and use)	0.03	2.00	0.06
3	Lack of R&D facilities on space technology and application in university and industry	0.04	2.00	0.08
4	Total industry spending for R&D	0.03	2.00	0.06
5	Lack of total numbers of engineers and expert in space technology and application sector.	0.05	2.00	0.10
6	Availability of specific study of space technology and application in local university	0.04	2.00	0.08
7	Supply chain of the satellite component	0.04	1.00	0.04
8	Manufacturing facilities	0.05	1.00	0.05
9	Synergy between government, industry and university	0.12	2.00	0.24
10	Technology readiness level (TRL) of Space Technology and Application in level 6–8	0.05	2.00	0.10
	Total (B)	0.50		0.58
	Total (A+B)	1.00		2.45

Tabel 6.
Opportunity

No.	External Factor	Weight	Rating	Weighted Score
	Opportunity			
1	Indonesia's Space Law No. 21/2013; the government will support the national satellite program, satellite infrastructure, satellite operation and launch activities	0.05	3.5	0.18
2	Competitive market of microsatellite in Asia and pacific region	0.05	2.5	0.13
3	Availability of off-the-shelf component for microsatellite technology	0.05	4	0.20
4	The real time data and information are increasingly needed for any business	0.04	3.5	0.14
5	Microsatellite technologies are available and the application technology also tends to increase (capacity and resolution)	0.06	4	0.24
6	President Decree No. 45/2017 on National Satellite Master Plan 2016–2040.	0.05	2.5	0.13
7	Availablity of MEMS Technology	0.05	2	0.10
8	Commercialization of satellite data and information	0.04	2.5	0.10
9	National Long-Term Development Plan (RPJPN 2005–2025); Emphasize on national economic development based on science and technology	0.07	2.5	0.16
10	Increasing trend on mastery of space technology in Asia region	0.04	2	0.08
	Total (A)	0.50		1.45

Tabel 7.
Threat

No.	External Factor	Weight	Rating	Weighted Score
	Threat			
1	International regulation of missile technology control regime (MTCR)	0.05	2	0.10
2	New product advance	0.03	3.5	0.11
3	US and Europe control the 3/4 of global satellite market	0.04	2	0.08
4	Regional political changing and open global information	0.08	2.5	0.20
5	The national political boundary	0.08	2.5	0.20
6	Restrictions on the use of hazardous component	0.04	3	0.12
7	Pollution industry and implemented nuke power in satellite technology	0.04	3	0.12
8	Space debris controlled by world body (UNOOSA)	0.04	4	0.16
9	Open trading for Asia country in unifie asian economics society since 2015	0.04	4	0.16
10	Satellite development is a high capital industry	0.07	3.5	0.25
	Total (B)	0.50		1.46
	Total (A+B)	1.00		2.90

Weakness/opportunity strategy:

1) Cooperation with new investor using Public Private Partnership scheme
2) Create the space technology and applications study program joint with technical university

Strenght/threat strategy:

1) Standardization of satellite system, product, method and human resources
2) Synergy of ministry and research institution in national satellite consortium

Weakness/threat strategy:

1) Utilized the opportunity of government cooperation

From SWOT method, there are nine strategic alternatives that meet the need of how the government is able to accelerate the national microsatellite industry. The nine strategic alternatives are:

1) Build the center of excellence for satellite technology.
2) Synergy of government, university and private company to create the start up space industry.
3) Microsatellite constellation project for support numbers of mission.
4) People space awareness.
5) New investor using PPP.
6) Create the space technology and applications study program joint with technical university.
7) Standardization of satellite system, product, metod and human resources.
8) Synergy of ministry and research institution in national satellite consortium.
9) Utilized the opportunity of government cooperation.

Finally, by using QSPM method, the precise strategy is decided from these nine strategic alternatives by measuring the attractiveness score of each alternative strategy. The attractiveness score of every strategy is higher if the strategy is very influential on these internal or external factors (David, 2011). The attractiveness score is in the range of 1.0 to 4.0 where 1.0 (not interesting), 2.0 (somewhat interesting), 3.0 (interesting) and 4.0 (very interesting). The results of the analysis produce numbers of attractiveness score from 9 strategic alternatives that will be selected against internal and external factors. Meanwhile, the total attractiveness scores (TAS) is the result of multiplication between the value of weight with the attractiveness score (AS) of each internal and external factor. The weight and attractiveness of every strategic alternative are measure and plotted in strategic matrix table. The selected pricise strategy is the strategy with highest TAS value in this matrix. The strategic matrix can be shown in Table 8 from QSPM.

The total attractiveness score of 9 selected strategic alternatives shown in table 9. From this stage, the highest attractiveness score can be chosen to be implemented in start the national satellite industry.

The chosen strategy was obtained from the highest attractiveness score. The three most attractive strategies are:

1) First: cooperation with new investor using PPP scheme (STAS = 5.426).
2) Second: standardization of satellite system, product, metod and human resources (STAS = 5.194).
3) Third: utilized the opportunity of government to government technical cooperation (STAS = 5.080).

The result of this research was obtained from identifying the external and internal factors, analyzing the factors and deciding the alternatives strategy which can be implemented for strengthening the national satellite industry especially on microsatellite program. Commercialization of national microsatellite and starting the start-up industry should be controlled by government using its regulation, financial scheme support, cooperation with national private company and increasing the numbers of qualified human resources using training and degree by research scheme joint with qualified universities. The proposal for industrial scheme to enhance the national capability in satellite technology can be seen at Figure 7. For the specific satellite industry the government has a significant role to conduct the whole system in the initial stage. Avalaibility of industry regulation, space activities regulation and long-term national space activities are the

Table 8. Strategic Matrix of National Micro Satellite Industry

	STRATEGIC FACTORS	WEIGHT	STRATEGIC ALTERNATIVES																	
			AS1		AS2		AS3		AS4		AS5		AS6		AS7		AS8		AS9	
	STRENGTH		AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS
S1	Vision of LAPAN; to be a national satellite excellence centre	0.06	2	0.12	2	0.12	2	0.12	3	0.18	4	0.24	3	0.18	2	0.12	2	0.12	2	0.12
S2	Ground station control and satellite data network worldwide	0.04	3	0.11	4	0.14	2	0.07	2	0.07	3	0.11	3	0.105	2	0.07	3	0.105	2	0.07
S3	Experience on operation and maintenance of microsatellite in LEO orbit	0.05	2	0.09	4	0.18	4	0.18	2	0.09	4	0.18	3	0.135	2	0.09	3	0.135	3	0.135
S4	experience on technology collaboration on satellite technology and application development with other space agency and international university	0.05	4	0.20	3	0.15	4	0.20	3	0.15	3	0.15	2	0.1	3	0.15	3	0.15	3	0.15
S5	Competency and experience of Engineers on microsatellite development and control.	0.06	4	0.24	3	0.18	3	0.18	3	0.18	3	0.18	2	0.12	3	0.18	3	0.18	3	0.18
S6	National Pride on space technology	0.06	2	0.12	3	0.18	2	0.12	4	0.24	2	0.12	3	0.18	3	0.18	3	0.18	2	0.12
S7	Infrastructure of imagery Laboratory, optic laboratory 10.000 class, Assembly Integration and Test Laboratory 100000 class for satellite.	0.05	4	0.20	3	0.15	4	0.20	3	0.15	4	0.20	3	0.15	3	0.15	3	0.15	2	0.1
S8	ICT infrastructure availability	0.06	2	0.11	2	0.11	2	0.11	2	0.11	2	0.11	3	0.165	3	0.165	3	0.165	3	0.165
S9	Experience on data utilization of communication and remote sensing technology as well	0.04	3	0.12	2	0.08	2	0.08	3	0.12	3	0.12	2	0.08	3	0.12	3	0.12	3	0.12
S10	Ability for managing the micro satellite orbital filling (LAPAN-TUBSAT, LAPAN-A2 and LAPAN-A3) at International Telecommunication Union (ITU) and International Amateur Radio Union (IARU)	0.05	2	0.09	1	0.045	1	0.05	4	0.18	2	0.09	2	0.09	2	0.09	2	0.09	2	0.09
	WEAKNESS																			
W1	Lack of budget for satellite research and development.	0.05	1	0.05	3	0.15	1	0.05	2	0.1	2	0.10	3	0.15	4	0.2	2	0.1	4	0.2
W2	Indonesia still in the position as data user only (receive and use)	0.03	2	0.07	2	0.068	3	0.10	2	0.068	3	0.10	3	0.102	3	0.102	3	0.102	4	0.136
W3	Lack of R&D facilities on space technology and application in university and industry.	0.04	3	0.12	3	0.12	2	0.08	2	0.08	3	0.12	3	0.12	3	0.12	4	0.16	4	0.16
W4	Total industry spending for R&D	0.03	1	0.03	2	0.062	2	0.06	2	0.062	2	0.06	2	0.062	2	0.062	2	0.062	2	0.062
W5	Lack of total numbers of engineers and expert in space technology and application sector.	0.05	2	0.10	3	0.15	2	0.10	2	0.1	2	0.10	4	0.2	3	0.15	4	0.2	3	0.15
W6	availability of specific study of space technology and application in local university	0.04	3	0.12	2	0.08	2	0.08	2	0.08	3	0.12	4	0.16	2	0.08	4	0.16	3	0.12
W7	Supply chain of the satellite component	0.04	3	0.12	2	0.08	1	0.04	1	0.04	3	0.12	3	0.12	4	0.16	1	0.04	2	0.08
W8	Manufacturing facilities	0.05	3	0.14	2	0.09	2	0.09	1	0.045	2	0.09	4	0.18	3	0.135	1	0.045	2	0.09
W9	Synergy between government, industry and university	0.12	2	0.24	3	0.36	2	0.24	2	0.24	3	0.36	3	0.36	4	0.48	2	0.24	3	0.36
W10	Technology Readiness Level (TRL) of Space Technology and Application in level 6-8	0.05	3	0.15	3	0.15	1	0.05	2	0.1	3	0.15	3	0.15	3	0.15	1	0.05	2	0.1
		1.00																		

	STRATEGIC FACTORS	WEIGHT	STRATEGIC ALTERNATIVES																	
			AS1		AS2		AS3		AS4		AS5		AS6		AS7		AS8		AS9	
	OPPORTUNITY		AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS
O1	Indonesia Space Law No.21/2013; the government will support the national satellite program, satellite infrastructure, satellite operation and launch activities.	0.05	3	0.15	2	0.10	3	0.15	2	0.1	3	0.15	3	0.15	3	0.15	4	0.2	3	0.15
O2	Competitive market of microsatellite in Asia and pacific region.	0.05	2	0.10	4	0.20	4	0.20	2	0.1	3	0.15	2	0.1	4	0.2	2	0.1	2	0.1
O3	Availability of off-the-shelf component for microsatellite technology	0.05	3	0.15	4	0.20	4	0.20	2	0.1	3	0.15	3	0.15	3	0.15	2	0.1	2	0.1
O4	The real time data and information are increasingly needed for any business.	0.04	2	0.08	2	0.08	4	0.16	2	0.08	2	0.08	2	0.08	2	0.08	1	0.04	2	0.08
O5	Microsatellite technologies are available and the application technology also tends to increase (capacity and resolution)	0.06	4	0.24	3	0.18	3	0.18	4	0.24	3	0.18	3	0.18	3	0.18	3	0.18	3	0.18
O6	President decree No.45/2017 on national satellite master plan 2016-2040.	0.05	2	0.10	2	0.10	3	0.15	2	0.1	2	0.10	2	0.1	3	0.15	3	0.15	2	0.1
O7	Availablity of MEMS Technology	0.05	4	0.20	3	0.15	2	0.10	2	0.1	2	0.10	3	0.15	3	0.15	3	0.15	3	0.15
O8	Commercialization of satellite data and information.	0.04	4	0.16	2	0.08	3	0.12	2	0.08	3	0.12	3	0.12	4	0.16	3	0.12	2	0.08
O9	National Long-Term Development Plan (RPJPN 2005–2025); emphasize on national economic development based on science and technology	0.07	2	0.13	4	0.26	3	0.20	2	0.13	3	0.20	2	0.13	3	0.195	3	0.195	2	0.13
O10	Increasing trend on mastery of space technology in Asia region	0.04	3	0.12	2	0.08	2	0.08	4	0.16	3	0.12	3	0.12	3	0.12	3	0.12	3	0.12
	THREAT																			
T1	International regulation of Missile Technology Control Regime (MTCR)	0.05	1	0.05	1	0.05	2	0.10	1	0.05	1	0.05	2	0.1	2	0.1	1	0.05	2	0.1
T2	New Product Advance	0.03	1	0.03	1	0.03	2	0.06	1	0.03	3	0.09	2	0.06	3	0.09	2	0.06	2	0.06
T3	US and Europe control the 3/4 of global satellite market	0.04	1	0.04	1	0.04	2	0.07	1	0.037	2	0.07	2	0.074	2	0.074	1	0.037	2	0.074
T4	Regional political changing and open global information	0.08	1	0.08	1	0.08	2	0.16	3	0.24	2	0.16	2	0.16	2	0.16	2	0.16	4	0.32
T5	The National Political boundary	0.08	1	0.08	1	0.08	1	0.08	3	0.24	1	0.08	1	0.08	1	0.08	2	0.16	2	0.16
T6	Restrictions on the use of hazardous component	0.04	1	0.04	1	0.04	1	0.04	1	0.04	1	0.04	1	0.04	1	0.04	1	0.04	1	0.04
T7	Pollution industry and implemented make power in satellite technology	0.04	1	0.04	1	0.04	1	0.04	1	0.04	1	0.04	1	0.04	1	0.04	1	0.04	1	0.04
T8	Space debris controlled by world body (UN)	0.04	1	0.04	1	0.04	3	0.11	1	0.038	2	0.08	1	0.038	1	0.038	1	0.038	1	0.038
T9	Open trading for Asia country in unifie asian economics society since 2015	0.04	2	0.07	2	0.07	2	0.07	1	0.035	4	0.14	2	0.07	3	0.105	3	0.105	2	0.07
T10	Satellite development is a high capital industry	0.07	2	0.14	2	0.14	3	0.21	1	0.07	4	0.28	2	0.14	3	0.21	3	0.21	4	0.28
		1.00		4.564		4.680		4.682		4.395		5.194		4.991		5.426		4.809		5.080

Table 9. Attractivenes Score from the Choosen Alternative Strategies

No	Alternatives Strategies	Sum Total Actractiveness Score (STAS)
1	Build the center of excellence for satellite technology.	4.564
2	Synergy of government, university and private company to create the start up space industry.	4.680
3	Microsatellite constellation project for support numbers of mission.	4.682
4	People space awareness.	4.395
5	Cooperation with new investor using PPP scheme.	5.426
6	Create the space technology and applications of joint-study program with technical university.	4.991
7	Standardization of satellite system, product, method and human resources.	5.194
8	Synergy of ministry and research institution in national satellite consortium.	4.809
9	Utilized the opportunity of government to government technical cooperation.	5.080

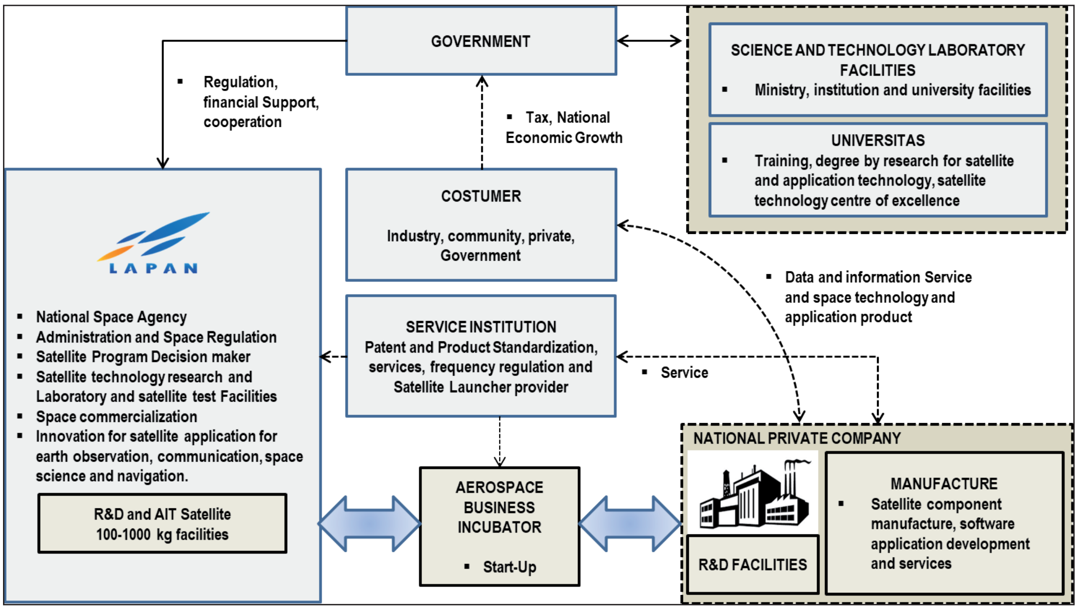


Figure 7. Microsatellite Industry Development Scheme

reference for government institution, academic and national private sectors. In this regard, firstly government has to provide all facilities for research and development of satellite technology include human resources capabilities program, international cooperation and collaboration also financial scheme support as well.

V. CONCLUSION

1) The role of government in supporting the national microsatellite industry is very dominant. In synergy with private sector and universities, then industrial ecosystem can be accelerated.
2) Commercialization of satellite product and services can be achieved by shifting the capability of experimental microsatellite to meet the international standard of system, method, product and human resources.
3) R&D of microsatellite can be done by collaboration of government, national private company and university.
4) Standardization of space product is based on ISO/TC20/SC14 (space systems and operations), such as ISO 10784-1 (early operations; space craft initialization and commissioning, initialization plan, commissioning report), ISO 10784-2 (design and operation), ISO 10784-3 (structural components and assemblies), and ISO/TR 11233:2014 (orbit determination and estimation process for describing techniques).